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Research Article

# LIQUID COMPOSITE THERMAL INSULATION COATINGS AND METHODS FOR DETERMINING THEIR THERMAL CONDUCTIVITY

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## ABSTRACT

The article describes the analysis of existing methods for determining the thermal conductivity of liquid composite thermal insulation coatings and the results of experimental studies on its improvement.

## KEYWORDS

Energy efficient, thermal insulation material, thermal conductivity, microsphere, thermal insulation paint, stationary method, non-stationary method, thermocouple sensors.

## INTRODUCTION

Energy conservation and energy efficiency issues are one of the most pressing issues in the world today, including the construction and operation of buildings and structures. This is due to the limited availability of energy sources, the high cost of energy and the negative impact it has on the environment as a result of its production.Currently, the construction market offers a variety of thermal insulation materials. Many new materials are being added to the

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existing range of polystyrene foam and mineral wool heaters for use in a variety of climates and construction conditions [1-3].

## THE MAIN PART

In recent years, thermal insulation paints based on hollow ceramics, glass and polymer microspheres have attracted a lot of attention.

These insulating paints are a high-tech composite material that forms an ultra-thin polymer coating with low thermal conductivity and excellent waterproofing and anti-corrosion (anti-slip) protection after drying.

The coating is designed for thermal insulation, waterproofing, protection against corrosion of thermal and engineering networks, process pipes, thermal energy and capacity equipment, and for thermal insulation and protection of facades and interiors of building structures, residential and industrial buildings.

This attention can be explained by the extremely low thermal conductivity of these dyes. For example, the thermal conductivity of Corundum paints is 0.001 W/m °C [1], while Bronya paint is 0.001 W/m • °C [2-7].

Of course, such a thermal conductivity coefficient gives preference to heat-insulating paints over conventional heaters (extruded foam polystyrene, mineral wool, etc.), so the thermal conductivity of extruded foam polystyrene is 0.030 W/m °C.

Therefore, the value of the thermal conductivity of liquid thermal insulation coatings has aroused the interest of both consumers and researchers, resulting in many experiments to determine the thermal properties and effectiveness of these paints. Under normal conditions, the thermal conductivity of air is 0.026 W/m•°C, and the thermal conductivity of an absolute vacuum is 0 W/m•°C [3].

Air is the best natural heat retainer [4-9].

The Tomsk State Institute of Architecture and Construction experimented on the method of GOST 7076-99 [5,11].

As a result of the work, the thermal conductivity of two dyes was determined - 0.086 W/m•°C and 0.091 W/m•°C. These results are much worse than those given by paint manufacturers [4,12].

The thermal conductivity of corundum paint was determined according to TU 5760-001-83663241-2008 by the method M-001-2003 [6-14], developed by the Research Institute of the Federal State Unitary Enterprise "Santechniki".

The development of this method was due to the fact that ultra-thin liquid composite coatings based on glass, aluminium silicate, perlite and similar microspheres are not suitable for determining the thermal conductivity by stationary and nonstationary methods [14,19]. Volgograd State University of Architecture and Construction was engaged in determining the thermal conductivity of corundum paint. The technical conclusion based on the test results states that the method for determining the thermal characteristics and the value of the thermal conductivity of corundum paint is 0.001 W/m•°C [17-22].

NIIMosstroy's technical conclusion based on the results of thermal engineering tests in accordance with GOST 26254-84 [8] concludes that the thermal conductivity value of Corundum-Facade thermal insulation coating is 0.12 W/m•°C and that this material is not suitable for thermal insulation of external walls [19-25].

Research conducted by the Siberian State Academy of Motor Road Construction has shown that heat loss in corundum-coated steel pipe is 20-30% lower than in unpainted pipe [10,26,27].

The differences between the results obtained can be explained primarily by the lack of normative methods for determining the thermal conductivity of new ultra-thin coatings based on microspheres. The structure of all such paints consists of grids of hollow microspheres interconnected with acrylic film-forming substances. Therefore, determining the true thermal conductivity of liquid thermal insulation coatings is one of the urgent tasks at the present time. At the "Youth Center for Innovative Technologies" of the Fergana Polytechnic Institute, research is being conducted to improve the method of determining the thermal conductivity of ultra-thin thermal insulation coatings. Based on the analysis of currently available methods in the development of the method, it was planned to replace the heat meter with a layer of material with a clear thermal conductivity using the standard method of determining the thermal conductivity of liquid thermal insulation coatings [5]. Such a substitution does not contradict the theory of the study of thermal processes [11-19].

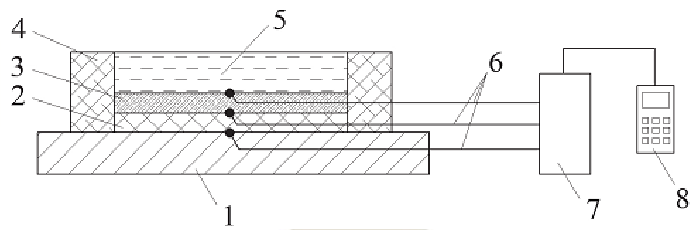


**Figure 1. Scheme of the device for determining the thermal conductivity of the liquid thermal insulation coating.**

1 stationary heat flow source; 2nd layer of concrete material with thickness and thermal conductivity (orgsteklo $\delta$ = 3.2 mm, l = 0.19 W/(m • °C); 3rd layer of thermal insulation coating; 4th layer of thermal insulator (foam); refrigerator "(water-filled tank); 6- chrome Kopel thermocouples made of wire with thickness s = 0.2 mm; 7-switch; 8-thermocouple readings.

Procedure for determining the thermal conductivity of thermal insulation coating: The coefficient of thermal conductivity of liquid thermal insulation coating was calculated according to the following formula:

$$\lambda = \frac{d_u}{\frac{\Delta T_u}{q_u} - 2R_L}, (1)$$

Where $d_u$ – the thickness at the time of sample testing, m;

$\Delta T_u$ – the temperature difference at the surface of the test sample, °C;

$q_u$ - the density of the stationary heat flux passing through the test sample, W/m$^2$;

$R_L$ - the thermal resistance of the copper plate coated with the test sample (paint), (m$^2$•°C)/W.

The density of the stationary heat flux passing through the sample is given by the following formula:

$$q_u = \frac{\lambda_{2layer}(t_1 - t_2)}{\delta_{2layer}}, W/m^2; \quad (2)$$

Where λ and $\delta$ are the coefficients of thermal conductivity and thickness of the orgstekloni $t_1$, $t_2$ are the temperatures at the boundaries of the "heat source - orgsteklo layer" and "orgsteklo layer - test specimen", respectively.

The thermal conductivity of a copper plate with a thickness $\delta$ = 0.5 mm is λ = 384/(m °C).

To stabilize the performance of the equipment during the study, the readings of the three thermocouple sensors were measured at 0.5 h intervals of 5 min to "heat up" all its parts and to stabilize the heat flow transmission [25-29].

From the graph given in Figure 2, it can be seen that the equipment readings became stationary after 15 minutes. To calculate the individual error of the thermocouple sensors, before starting the experiments, the temperature of each sensor immersed in a Dewar vessel filled with melted ice was measured and the temperature deviation from 0 °C was taken into account during the experiments.

To determine the reliability of the equipment for measuring the thermal conductivity of thermal insulation paint, initial tests were carried out.

Instead of the 3rd layer in the device (Fig. 1), an orgsteklo plate similar to the 2nd layer in terms of size, thickness and thermal conductivity was placed and its thermal conductivity was measured.

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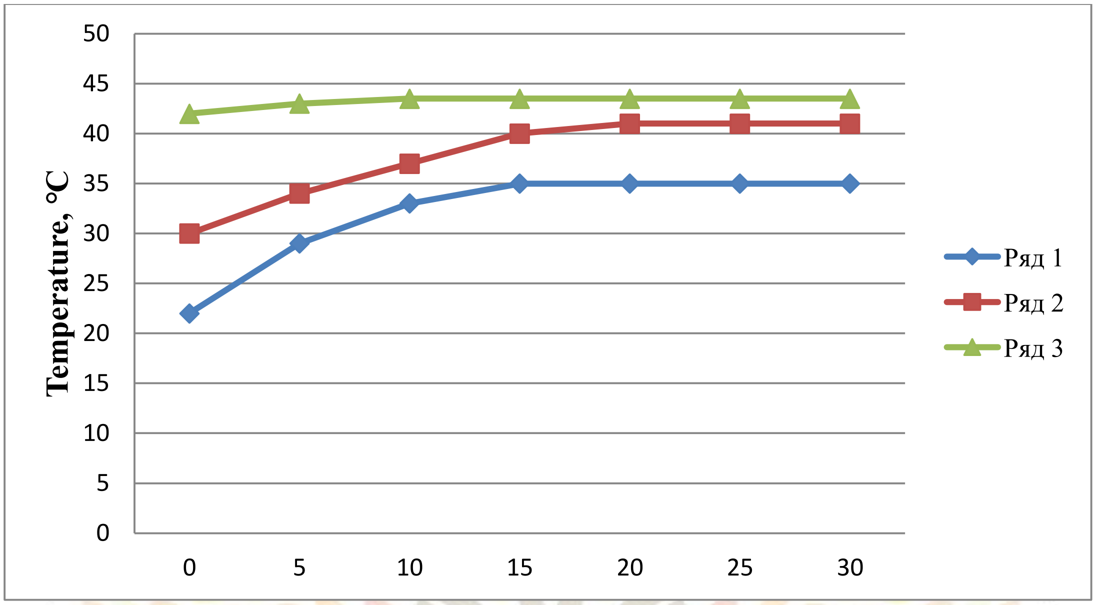


**Time, minutes**

**Figure 2. Indicators of the three thermocouple sensors of the equipment**

The measurement results showed that the thermal conductivity of the tested org-glass plate was λ=0,186 W/(m·°C). In this case, the error of the method of determining the thermal conductivity:

$\Delta = \frac{0{,}19-0{,}186}{0{,}19} 100 = 2{,}1\%$ and this error are not more than the error (± 3%) given in GOST [5].

Also, it shows the correctness of the selected research scheme. In recent years, the Fergana Polytechnic Institute in collaboration with Ferganaazot has conducted significant research on liquid heat-resistant insulation coatings created by means of hollow microspheres and various binders (analogue of our heat-saving coating).The effectiveness of thin-layer heat-insulating coatings used in heat supply systems was determined, the technical and economic efficiency of the use of these coatings was assessed.

At the BAM workshop of the Center for Energy Saving Technologies, the effectiveness of the application of energy-saving coatings on the D76 mm gate valve of the heating steam supply pipe to the station consumers was evaluated.

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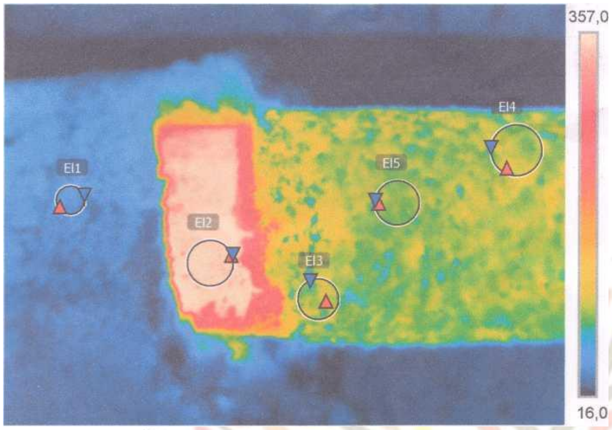


| | | |
|---|---|---|
| **EI1** | **Max** | **77,6 □** |
| | **Min** | **56,5 □** |
| **EI2** | **Max** | **354,8 □** |
| | **Min** | **326,2 □** |
| **EI3** | **Max** | **159,7 □** |
| | **Min** | **99,1 □** |
| **EI4** | **Max** | **163,9 □** |
| | **Min** | **126,5 □** |
| **EI5** | **Max** | **152,4 □** |
| | **Min** | **111,0 □** |

**Figure 3. Photo of paint coating.**

The inspection was outdoors. The coating is laid in 3 layers. The final thickness was 3 mm. Total coating consumption was 0.9 litres.

Data for calculation:

Dpipe = 76 мм.;

Wall = +410 °C (without insulation);

Wall- +18,4 °C (with coating);

F- area of the gate valve top = 0.3 m2;

1.58 W/m2K for heat-insulated plots;

12 W/m2K for thermally uninsulated plots;

According to calculations, the heat loss from an uninsulated gate valve is 108.9 Kcal/h, insulated - 9.13 Kcal/h.

The efficiency calculation showed that the coating allows reducing the heat loss from the surface of the valve with a diameter of 76 mm from 108.9 to 9.13 (Kcal/h).

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